Unpolarized Light for Grating Simulation – Discussion at Examples
Optical devices like gratings are sensitive to the polarization of the light. Thus, it is important to properly consider the polarization of light in the simulation. In practice, gratings sometimes work with unpolarized light as input. We show how to model such unpolarized light, as the average of two orthogonal polarization states, for grating simulation in VirtualLab Fusion. Examples are provided to illustrate the corresponding settings in the software.


Unpolarized Light in Grating Simulation

• Grating analysis
  – For single grating analysis with the Fourier modal method (FMM / RCWA), plane wave incidence is used to calculate e.g. the diffraction efficiencies as the intrinsic properties of the grating under investigation.

• Unpolarized plane wave
  – Considering a plane wave along the z direction, unpolarized light can be thought of as that which, statistically, may take any polarization state at one time.
  – An arbitrary polarization state can be projected on two orthogonal states; unpolarized light gives, statistically, equal projections along the two states forming this orthogonal basis.
  – Thus, we can use the average of the two orthogonal states, in an incoherent manner, to represent unpolarized light.
Light Source Settings in Grating Simulation

• Manual control of source polarization states
  - Light is always represented in vectorial form in VirtualLab Fusion and the user has full control over the polarization state in the source settings.
  - Following the basic concept, one can perform grating simulations with specific input polarization states as needed for unpolarized light. For example, by choosing TE and TM polarizations as the two orthogonal basis states, we can perform the grating simulation independently for both configurations, and then manually average the results via ribbon-menu functions (as explained in what follows).
Polarization-Dependent Analyzer in Grating Simulation

• Polarization analyzer for gratings
  - For grating diffraction efficiency calculation, VirtualLab Fusion provides the Polarization Analyzer, for the investigation of polarization-dependent effects.
  - The polarization analyzer, in comparison to the grating order analyzer, has additional control over the polarization states of the incidence.
  - The polarization settings in the polarization analyzer work independently from the source settings in the optical setup.

![Edit Polarization Analyzer window](image)
Example #1: Talbot Images with Unpolarized UV Light
The Talbot image $|E|^2$ of the phase mask is to be calculated at a selected position, with unpolarized UV light illumination.

see the full Application Use Case
Detected Fields at a Certain Position

Unpolarized plane wave modeled as combination of:
- x-polarized (TM)
- y-polarized (TE)

We set the incident plane wave in the TE-TM coordinate system, with linear polarization angles 0° and 90°, here for normal incidence, exactly along x- and y-direction.
Detected Fields at a Certain Position

unpolarized plane wave modeled as combination of
- x-polarized (TM)
- y-polarized (TE)

transmitted field components from x-polarized input

transmitted field components from y-polarized input

z=120nm
Incoherent Summation

- The incoherent summation of the results from two linearly polarized input beams can be done via ribbon-menu functions.
- To perform the incoherent summation, one should convert the intensity data into a Numerical Data Array document.
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- To perform the incoherent summation, one should convert the intensity data into a Numerical Data Array document.

Remember that the quantity $|E|^2 = |E_x|^2 + |E_y|^2 + |E_z|^2$ is to be calculated.
Incoherent Summation

By the same process, the intensity from the y-polarized input is also converted into a Numerical Data Array document.

The incoherent summation of both results can be done as follows:

- sequentially select both documents and press “+” on the keyboard, or
- via the ribbon menu of VirtualLab Fusion:
The choice of the two orthogonal input polarization states is arbitrary.

The resulting Talbot images are independent of the choice of the two orthogonal input polarization states.
Example #2: Analysis of Polarization Independent Transmission Gratings
Modeling Task

The diffraction efficiency of the -1\textsuperscript{st} order, with unpolarized incidence, is to be calculated.

input plane wave
- wavelength 1060 nm
- unpolarized (averaging TE and TM)
- Littrow configuration

fused silica
n = 1.45

Air

Grating parameters

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see the full Application Use Case
Polarization Analyzer for Gratings

- input plane wave
  - wavelength 1060nm
  - unpolarized (averaging TE and TM)
  - Littrow configuration

- The polarization analyzer does the job of averaging the diffraction efficiencies for selected orders, with $E_x$ and $E_y$ polarizations as the input.

- display of the results from the polarization analyzer
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